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28 May 1965

COMPONENT DEVELOPMENT SPECIFICATION

TRANSDUCER, FULL BRIDGE, STRAIN-GAGE, WELDABLE,
RADIATION RESISTANT, GENERAL SPECIFICATION FOR (U)

CODE IDENT NO. 05824

MASTER

AEROJET-GENERAL CORPORATION

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1. SCOPE

1.1 Scope. - This specification covers full bridge, weldable, radiation resistant, strain-gage transducers.

1.1.1 Description. - The full bridge transducer, hereinafter called a strain-gage, consists of two parallel sensing tubes attached to a weld flange with provision for completing the bridge wiring. Each sensing tube contains an active (strain sensitive) element and a dummy (temperature compensation) element.

2. APPLICABLE DOCUMENTS

2.1 Department of Defense documents. - Unless otherwise specified, the following documents, listed in the issue of the Department of Defense Index of Specifications and Standards in effect on the date of invitation for bids, shall form a part of this specification to the extent specified herein.

SPECIFICATIONS

Military

MIL-E-5272

Environmental Testing, Aeronautical
and Associated Equipment, General
Specifications for
Calibration System Requirements

MIL-C-45662

STANDARDS

Military

MIL-STD-105

Sampling Procedures and Tables for
Inspection by Attributes

MIL-STD-129

MIL-STD-143

Marking for Shipment and Storage
Specifications and Standards, Order
of Precedence for Selection of

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MS33586

Metals, Definition of Dissimilar

(Copies of documents required by contractors in connection with specific procurement functions should be obtained as indicated in the Department of Defense Index of Specifications and Standards.)

2.2 Other documents. - Unless otherwise specified, the following documents, of the issue in effect on the date of invitation for bids, shall form a part of this specification to the extent specified herein.

PUBLICATIONS

National Aeronautics and Space Administration

NPC 200-3

Inspection System Provision for Supplies
of Space Materials, Parts, Components
and Services

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington 25, D. C.)

Marshall Space Flight Center

Engineering Standards Manual (5 volumes)

(Copies of MSFC Publications may be obtained from the Propulsion and Vehicle Engineering Division, Building 4610, George C. Marshall Space Flight Center, Huntsville, Alabama.)

2.3 Aerojet-General Corporation documents. - Unless otherwise specified, the following documents, of the latest issue in effect, shall form a part of this specification to the extent specified herein.

SPECIFICATIONS

AGC-46350

AGC-46387

Levels of Cleanliness, Description of
Packaging Requirements and Product
Environmental Capabilities

STANDARDS

ASD5215

QCS B-9-1-4

Marking, Methods of
Quality Control Standard: Inspection System
Provisions for Suppliers of Materials,
Components and Services.

3. REQUIREMENTS

3.1 Order of precedence. - The requirements stated herein are applicable to all full bridge, weldable, radiation resistant, strain-gage transducers. Detail requirements or exceptions applicable to individual strain gages shall be specified in a component specification sheet for that strain gage. Each strain gage shall meet the requirements of this specification, the applicable component specification sheet, and the applicable Aerojet-General Corporation (AGC) drawing. In the event of conflict between the requirements of these documents, the following order of precedence is established:

- (a) Requirements of the applicable drawing
- (b) Requirements of the applicable component specification sheet
- (c) Requirements of this specification

3.2 Selection of specifications and standards.- Specifications and standards necessary for the procurement of components, materials and services shall be selected in accordance with applicable documents as established by Marshall Space Flight Center (MSFC and ABMA) and Standard MIL-STD-143 (see 2.1).

3.2.1 Standard parts and design standards.- Wherever practicable, standard parts and design standards shall be selected from the MSFC Engineering Standards Manual (see 2.2). Standard parts shall be identified by their standard part number.

3.3 Materials.- All materials used shall be compatible for use in water, in liquid and gaseous oxygen, nitrogen and hydrogen, and in air. The materials of the case, insulation and leads shall be suitable for the requirements specified herein and on the component specification sheet.

3.3.1 Weldability.- The strain gage shall be of proper material to permit attachment by resistance welding to 6061-T6 aluminum or to AISI347 steel in accordance with the component specification sheet.

3.3.2 Dissimilar metals.- Unless suitably protected against electrolytic corrosion, dissimilar metals as defined in Standard MS33586 shall not be used.

3.4 Design.-

3.4.1 Rating.- Each strain gage shall meet the operational ratings specified on the applicable component specification sheet and shall be satisfactory for 3600 seconds of continuous use under the environmental conditions herein specified.

3.4.2 Output polarity.- The bridge shall be so wired that the positive output represents compression.

3.4.3 Resistance.-

3.4.3.1 Element.- The resistances of the strain gage shall be as stipulated on the applicable component specification sheet.

3.4.3.2 Insulation.- Insulation resistance, as measured between the leads and the case, shall not be less than 200 megohms at 50 vdc.

3.4.4 Excitation current.- The strain gage shall be designed for continuous service within the operating temperature range of 3.4.6 with an excitation current of 50 milli-amperes through each element.

3.4.5 Excitation voltage.- The excitation voltage shall be in accordance with the applicable component specification sheet.

3.4.6 Temperature range.- The strain gage shall be capable of operation over a temperature range of -350° to +350°F. The strain gage shall be temperature compensated over the range specified in the applicable component specification sheet.

3.4.7 Gage factor. - At 75°F the gage factor of each active element of each instrument shall be between 1.5 and 2.0 and shall be within ± 3.0 percent of the gage factor of any other active element of the purchased lot.

3.4.7.1 Change in gage factor with temperature. - The gage factor shall not change from the value established at 75°F by more than 0.01 percent per Fahrenheit degree when subjected to any temperature in the range from -350° to +350°F.

3.4.8 Apparent strain with temperature change. - When the strain gage is welded to the item being instrumented, the apparent strain indication due to temperature shall be within the limits specified in the applicable component specification sheet when the temperature is varied from the balance temperature of $75^\circ \pm 50^\circ\text{F}$ to any temperature in the temperature compensation range specified in the applicable component specification sheet.

3.4.9 Non-linearity and hysteresis. - Errors caused by non-linearity and by hysteresis shall not exceed ± 1.0 percent of the measurement.

3.4.10 Hermetically sealed. - The strain gage shall be hermetically sealed.

3.4.11 Strain range. - The measurement range of the strain gage shall be ± 6000 microinches per inch.

3.5 Environmental requirements. - The strain gage shall be capable of withstanding the following environmental conditions singly or in combinations that may occur in service and shall be capable of meeting the rating requirements of 3.4.1 during and after exposure to those conditions. Unless otherwise indicated, the following conditions occur during periods of operation and non-operation of the strain gage.

(a)	Relative humidity, percent	100
(b)	Temperature, °F	
	Low	-350
	High	+350
(c)	Acoustical, decibels	0 to 170
	(Reference level: 0.0002 dynes/cm ²)	
(d)	Sand and dust	MIL-E-5272, Proc. I
(e)	Vibration	

Sinusodial

<u>Frequency range</u> <u>cps</u>	<u>Displacement-in.</u> <u>(double amplitude)</u>	<u>Acceleration-"g"</u> <u>(0 to peak)</u>
1 to 18	0.25	- -
18 to 45	- -	1.5
45 to 2000	- -	2.0

Transient

75 g, 0 to peak

Random

32 g root mean square at 0.50 g²/cps for 7.5 minutes, 0 to 2000 cps spectrum

(f) Shock

6.5 milliseconds terminal peak sawtooth at 30g

3.5.1 Radiation.- The strain gage shall be designed to operate satisfactorily in the following radiation environments:

(a) Neutron flux (fast), n/cm ² -sec E > 0.9 Mev	3.0 x 10 ¹⁴
(b) Neutron flux (thermal), n/cm ² -sec E > 0.41 Mev	2.0 x 10 ¹³
(c) Gamma flux (thermal), ergs/gm(C)-hr	3.0 x 10 ¹¹
(d) Fast neutron integrated flux, n/cm ²	1.1 x 10 ¹³
(e) Fast neutron thermal flux, n/cm ²	7.2 x 10 ¹⁶
(f) Fast neutron gamma flux, ergs/gm(C)	3.0 x 10 ¹¹

3.6 Cleanliness.- The strain gage shall be cleaned to comply with Level H of Specification AGC-46350 and inserted in a sealed plastic bag prior to packaging.

3.7 Identification marking.- All strain gages shall be permanently marked in accordance with Standard ASD5215. Identification marking shall include, but not be limited to the requirements of the applicable AGC drawing.

3.8 Storage life.- The strain gage, when packaged for storage, shall be capable of being stored under shelter conditions for one year before being placed into service. The strain gage shall not deteriorate or fail to operate after being stored for the period specified.

3.9 Workmanship.- The workmanship shall be of sufficiently high grade to insure satisfactory operation, reliability and durability consistent with the service life of the strain gage and the requirements of this specification. The interior of the strain gage shall be free of metal filings, grease or oil, foreign material, dust or other loose particles which might interfere with normal operation. Particular attention shall be paid to neatness and thoroughness of plating, identification marking, welding and freedom of parts from burrs and sharp edges.

4. QUALITY ASSURANCE PROVISIONS

4.1 Supplier responsibility.-

4.1.1 Inspection.- Unless otherwise specified, the supplier is responsible for all inspection requirements and tests specified herein and may use any facilities acceptable to AGC. The procuring agency reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.2 Supplier's changes.- The supplier shall not make the following changes without first submitting the proposed changes in writing to the cognizant AGC (REON) design engineering department for written approval.

- (a) Any change to the parts or to the drawings defining the parts supplied under this specification.
- (b) Any changes in the processing techniques.

4.1.3 Supplier's warranty.- The supplier shall perform the acceptance tests on each unit shipped. Each unit shall be accompanied by three copies (each) of the supplier's calibration records. Additional records of test data are stipulated in 4.4.1 and 4.4.2.

4.2 NASA Publication NPC 200-3.- Quality assurance provisions shall be in accordance with the specific and applicable portions of NASA Quality Publication NPC 200-3 as interpreted by AGC Standard QCS B-9-1-4 (see 2.3) and specified in the contract or order, except that the supplier shall not be required to divulge proprietary procedures and processes, nor to maintain traceability of raw materials prior to fabrication.

4.3 Classification of tests.-

4.3.1 Acceptance tests.- Each strain gage shall be subjected to the tests specified herein and to any additional or modified tests as may be specified on the applicable component specification sheet and the AGC drawing. The failure of any strain gage to meet the requirements of any acceptance test shall be cause for rejection of that particular gage. Individual strain gages that are rejected may be returned to the supplier for rework. Reworked gages shall be submitted for retest separately from any other contract shipments. At the discretion of the supplier, new strain gages may be submitted for defective gages in lieu of rework. Such new strain gages shall be properly identified to distinguish them from the reworked gages. Acceptance tests shall consist of the tests specified in 4.5.1, 4.5.2 and 4.5.3. After acceptance testing has been completed, each strain gage shall be cleaned to comply with the cleanliness requirements of Specification AGC-16350, Level II, and packed in a sealed plastic bag (see 3.6).

4.3.2 Additional tests.- At the discretion of the Aerojet-General Corporation, samples will be selected from each lot, in accordance with Standard MIL-STD-105, after completion of the acceptance tests and the following additional test performed by AGC:

- (a) Apparent strain with temperature change (see 4.5.6)

The failure of any strain gage to meet the requirements of this test shall be cause for rejection of the entire lot.

4.3.2.1 Radiation tests.- Testing to determine the effects of radiation on the strain gage may be done by AGC at the discretion of AGC.

4.4 Test conditions.-

4.4.1 Test data.- A reproducible copy of the supplier's inspection data, test data and gage factor data shall be included with each strain gage shipped.

4.4.2 Certification.- The supplier shall certify:

- (a) That the gage factor of any instrument in the lot is within ± 3 percent, at $75^\circ \pm 5^\circ\text{F}$, of the statistically determined value.
- (b) That the gage factor shall not change from the value established at $75^\circ \pm 5^\circ\text{F}$, by more than 0.01 percent per Fahrenheit degree when subjected to any temperature in the range from -350° to 350°F .

- (c) The unmounted terminal slope value, the temperature extremes over which the slope measurement is made and the material for which the strain gage is temperature compensated.

4.4.3 Test equipment.- The supplier's test equipment shall meet the requirements of Specification MIL-C-45662.

4.4.4 Test procedures.- The suppliers shall provide AGC with a detailed description, in document form, of the proposed acceptance test procedures and required test equipment two weeks prior to the start of testing, for AGC comment and approval.

4.5 Tests.- Unless otherwise specified, all tests shall be performed at room ambient temperature, pressure and humidity. The testing of the strain gage shall be in accordance with the following:

4.5.1 Examination.- Each strain gage shall be examined externally for conformance to the requirements of this specification, the applicable component specification sheet and the applicable AGC drawing.

4.5.2 Calibration.- When specified in the applicable component specification sheet, the gage factors of the two active elements of each strain gage shall be measured with an accuracy of ± 1.0 percent after fabrication and initial temperature compensation of the element sub-assembly. The acceptance test of this requirement may be accomplished by approval of data submitted and by certification (see 4.4.1 and 4.4.2).

4.5.3 Resistance.-

4.5.3.1 Element.- The input and output resistances of the strain gage shall be in accordance with the requirements of the applicable component specification sheet.

4.5.3.2 Insulation.- Each strain gage shall be completely immersed in hot water ($180^{\circ} \pm 20^{\circ}\text{F}$) for not less than 10 minutes. Upon withdrawal from the hot water, the resistance of the insulation, as measured between the leads and the case, shall not be less than 200 megohms.

4.5.4 Shock.- While non-operative, the strain gage shall be subjected to a shock loading of 6.5 millisecond terminal peak sawtooth at 30 g. The gage shall then be operated and shall perform without malfunction.

4.5.5 Vibration.- The strain gage shall satisfy all performance requirements while being subjected to the vibration conditions of 3.5.

4.5.6 Apparent strain with temperature change.- The strain gage shall be resistance welded to a metal sample of the type specified in the applicable component specification sheet to simulate use conditions. The strain gage shall then be balanced at $75^{\circ} \pm 50^{\circ}\text{F}$. The test unit shall be lowered in temperature to the low temperature specified in the applicable component specification sheet and allowed to stabilize before strain readings are recorded. The test unit shall then be brought to the high temperature specified in the applicable component specification sheet and allowed to stabilize before strain readings are recorded. The apparent strain indication due to temperature shall be within the limits specified in the applicable component specification sheet.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packaging and packing.- Preservation, packaging and packing shall be in accordance with Specification AGC-46387, Class III.

5.2 Marking.- Unit packages and shipping containers shall be marked in accordance with Standard MIL-STD-129. Marking shall include, but not be limited to, the following information:

- (a) Supplier's name
- (b) Part name
- (c) Lot number
- (d) Serial number
- (e) Date of manufacture
- (f) Number and date of this specification
- (g) Unusual storage requirements, if required
- (h) Net weight

6. NOTES

6.1 Intended use.- The strain gage covered by this specification is intended for mounting on components such as the pressure vessel and nozzle during engine tests in the NERVA Program.

6.2 Definitions.-6.2.1 Gage factor.-

$$\text{Gage factor} = \frac{\Delta R/R}{\Delta L/L}$$

Where $\frac{\Delta R}{R}$ = incremental change in resistance
 and $\frac{\Delta L}{L}$ = incremental change in length

6.2.2 Non-linearity.- Non-linearity is the deviation of the output at any measured point from the corresponding point on the straight line with end points fixed at 0 and 100 percent of both measurand and output. It shall be expressed at any measured point as a percent of the 100 percent output value.

6.2.3 Hysteresis.- Hysteresis is defined as the difference between the output of the instrument in response to a decreasing stimulus and the output in response to an increasing stimulus.

6.2.4 Apparent strain with temperature.- Apparent strain with temperature is defined as that portion of the output of the instrument which results from dimensional changes in the test specimen as a function of the thermal coefficient of linear expansion of the test material.

Authorized for Release:

R. H. Benedict

R. H. Benedict

Specifications and Standards

Project Engineering Division - REON

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SIGNATURE SHEET

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Document Prepared by M. N. Rosenthal, Dept. 7430

Document Checked by H. R. Harper, Dept. 7461

APPROVAL SIGNATURE

DEPT.

DATE

I. L. Odgers, Manager
Component Development Division - REON

7461

6-4-65

W. P. Gilles, Senior Dept. Manager
Instrumentation - REON

7461

6-4-65

W. A. Chapla, Manager
Product Assurance Engineering - REON

7350

6-3-65

G. Kaveney, Manager
Structures - REON

7421

6-4-65

P. W. Rowe, Manager
Project Engineering Division - REON

7430

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